APPENDIX A

BIOGRAPHICAL SKETCHES OF ADVISORY PANEL MEMBERS

Richard J. Roth, Jr., Co-Chair

Richard J. Roth, Jr., was appointed to the position of Assistant Insurance Commissioner and Chief Property/Casualty Actuary, State of California, on July 1, 1984. Roth joined the Department of Insurance as a property/casualty actuary in March, 1981.

He is responsible for issues relating to property and liability insurance, specifically reinsurance, workers' compensation, medical malpractice, mortgage guaranty, public liability, commercial, and the availability and affordability of automobile insurance. He is the author of the Department's annual report on earthquake insurance. As the Chief Property/Casualty Actuary, Roth is involved in issues of solvency, financial reporting, and the actuarial portion of the financial examination of property/casualty companies.

Roth is a Fellow of the Casualty Actuarial Society and received a Bachelor of Science in Mathematics in 1964 and Masters degrees in Economics and Statistics in 1970 from Stanford University. He also holds a law degree and is a member of the Connecticut State Bar. Prior to entering the insurance profession, he was an aeronautical engineer for six years.

D. Ward, Co-Chair

A licensed architect, Del Ward currently is a consultant in building technology and also serves as an adjunct faculty member in the Graduate School of Architecture, University of Utah. In both capacities, his principal work pertains to building technology and structural systems.

Architectural education has been the predominant activity of his career. He began his teaching career at Columbia University, New York City, in 1958. From 1960 to 1975 he was a Professor of Architecture at the University of Utah. After that he joined the State University system of Florida for two years, where he assisted in organizing the Florida Solar Energy Center, and energy research center. Since 1981 he has engaged in private architectural practice and consulting.

His involvement in architectural aspects of seismic design spans a period of more than twenty years and a number of activities, beginning in an academic research setting. From 1977 to 1981, he was executive director of the Utah Seismic Safety Advisory Council, a state agency established by legislative act to recommend and guide Utah's earthquake programs. He has served on the Board of Directors of the Earthquake Engineering Research Institute and chaired the Public Policy and Publications Committees of that organization. Additionally, he has served on research review committees for the National Academy of Sciences, the National Science Foundation, and the Federal Emergency Management Agency, either directly or through contractors to those agencies.

Since 1985, he has served on the examination-writing committee of the National Council of Architectural Registration Boards, the professional organization through which architectural licensing examinations are prepared. His involvement with that group has been in the divisions of general structures and lateral forces.

Published reports, papers, lectures, and technical studies by Mr. Ward number in excess of 150. These writings appear in various books, journals, proceedings, and separate booklets. All of the published work deals with building technology.

Most recently, Mr. Ward is co-author of a book on seismic design principles for architects titled Seismic and Wind Loads in Architectural Design: An Architect's Study Guide. A second edition of the work will be released by the American Institute of Architects in June of 1990. This book is a principal reference for architects preparing for licensing examinations.

James E. Beavers, Ph.D., P.E.

Dr. Beavers currently serves on the Board of Directors of the Earthquake Engineering Research Institute and is editor of the Institute's professional journal Earthquake SPECTRA. He served as chairman of EERI's "Third U.S. National Conference on Earthquake Engineering" held in Charleston, SC (1986) and has been a member of the Strong Motion, Public Policy and Nominating committees. He was also a principal organizer of the first major earthquake conference to focus on earthquake hazards and risks in the eastern U.S. held in Knoxville, Tennessee (1981) and was editor of the two volume proceedings "Earthquakes and Earthquake Engineering: The Eastern United States." He is a member of the National Academy of Sciences and Engineering's National Research Council Committee on Earthquake Engineering and was chairman of its Advisory Panel for a National Earthquake Engineering Experimental Facility. He is a member of the Scientific Advisory Committee for the National Center for Earthquake Engineering Research, has served as a member of the National Science Foundation's Advisory Panel for Critical Engineering Systems and a chairman of the Seismic Advisory Panel for the Governor of Tennessee.

Dr. Beavers has been chairman or a member of numerous other national, state and local professional committees; has authored or coauthored over fifty papers, articles and reports; has been guest lecturer/invited speaker at over fifty university and civic functions; has lectured for the International Atomic Energy Agency's Nuclear Power Program at Argonne National Laboratory; and has taught at the University of Tennessee. His professional honors include National Outstanding Young Engineer by the National Society of Professional Engineers (1977), Rotary Foundation exchange program participant with the peoples of India (1980), Honor Member of the National Civil Engineering Rolla (1987), Outstanding Technical Achievement Award - Martin Marietta Energy Systems, Inc. (1987), Engineer of the Year - State of Tennessee (1987), National Award of Merit - American Society for Engineering Management (1989), and appointment as a Martin Marietta Fellow (1990).

He received his B.S. degree in Civil Engineering from the University of Missouri at Rolla and his M.S. and Ph.D. degrees in Structural Engineering from Vanderbilt University. He is a registered Professional Engineer in Tennessee and Mississippi and is a member of several technical and professional societies, including the American Society of Civil Engineers (Fellow), the Seismological Society of America and the National Society of Professional Engineers. He has served as President of the Knoxville Branch, Tennessee Valley Section and Tennessee Section of ASCE; President of the Oak Ridge Chapter, Tennessee Society of Professional Engineers and Vice President of the Tennessee Society of Professional Engineers.

He is on the Senior Staff of the Engineering Divisions at Martin Marietta Energy Systems, Inc. which operates the Department of Energy's Oak Ridge National Laboratory, (Oak Ridge, TN), Uranium Enrichment Plants (Oak Ridge, TN; Paducah, KY; and Portsmouth, OH) and Y-12 Plant (Oak Ridge, TN) with over 18,000 employees.

George K. Bernstein

An attorney in Washington, D.C., and New York City, Mr. Bernstein advises and represents insurers, agents, brokers and State Insurance Departments on regulatory matters including the chartering and licensing of insurance companies, examinations, compliance with state law, ratemaking, as well as the rehabilitation and liquidation of financially troubled and insolvent insurers. He is also involved in the formation of offshore insurers and of risk retention groups.

Mr. Bernstein also represents insurers and insurance organizations in litigation and before Congress and state legislatures in such areas as financial deregulation, taxation, investment income, rating classifications, workers' compensation, occupational disease including asbestosis and agent orange, medical malpractice, automobile no-fault, and competitive rating. He is frequently called on to testify as an expert witness before legislative committees and in insurance litigation. He is also involved in public housing and real estate matters.

In 1974, Mr. Bernstein received the U.S. Department of Housing and Urban Development's "Distinguished Service Award".

Previously, from 1969 to 1974, Mr. Bernstein served as the first Federal Insurance Administrator. In March of 1972, he was also appointed Administrator of the federal Office of Interstate Land Sales Registration (OILSR). He served in both positions in the U.S. Department of Housing and Urban Development until November 1974, when he resigned to return to the private practice of law. As head of the Federal Insurance

Administration, Mr. Bernstein administered the National Flood Insurance Program, the Federal FAIR (Fair Access to Insurance Requirements) Plan and Riot Reinsurance Program, and the Federal Crime Insurance Program. He also acted as insurance advisor to the White House, and frequently testified before various Congressional committees on behalf of the White House and HUD and as an expert witness. As Interstate Land Sales Administrator, Mr. Bernstein implemented the 1968 federal law requiring full disclosure and registration of unimproved property sold in interstate commerce.

Before coming to Washington in 1969, Mr. Bernstein served with the New York State Insurance Department, first as Deputy Superintendent and General Counsel (beginning in 1964), and from 1967 as First Deputy Superintendent. Before his appointment to the Insurance Department in 1964, Mr. Bernstein practiced law, primarily in the field of insurance, in New York City.

Earlier, from 1957 to 1961, as Assistant Attorney General of the State of New York in the Litigation and Appeals Bureau, he argued more than 50 appeals in the State and Federal Courts, many of which resulted in landmark decisions in the area of federal-state relations and criminal constitutional law. Among the state agencies that he represented during this period was the New York Insurance Department, and many of the matters he handled had precedent-setting impact on the insurance business and its regulation.

Mr. Bernstein received his B.A. from Cornell University in 1955 and his LL.B. from Cornell Law School in 1957. At law school, he has the winner of the Moot Court Competition and was Chairman of the Moot Court Board.

He was admitted to the New York Bar in 1957, the United States Court of Appeals, Second Circuit, in 1958, the United States Supreme Court in 1972, and the District of Columbia Bar in 1973.

Mr. Bernstein has also served as a United States Delegate to the NATO Conference on Flood Insurance, 1970; United States Government Consultant to the Japanese Government on Flood and National Disaster Insurance, 1972; Special Counsel to the New York Select Committee on Insurance, 1974-1976; Consultant to the Overseas Private Investment Corporation, 1975-1977 and 1983-1984; Consultant to the President's Commission for the Study of Ethical Problems in Medicine and Biomedical and Behavioral Research, 1979-1981.

He was a member of the President's Interdepartmental Committee on Medical Malpractice, 1971-1973; the National Academy of Sciences' Committee on Medical Malpractice, 1972-1973; the Advisory Committee to the New York State Legislature on Recodification of the Insurance Law, 1972-1974; the President's Interdepartmental Study on Workers' Compensation, 1973-1974; and the National Insurance Development Program Advisory Board, 1976-1977.

He recently served as Chairman of the Expert Review Committee for the National Earthquake Hazards Reduction Program. Since 1983, he has been court-appointed Agent for the Vermont Insurance Commissioner as Receiver of the insolvent Ambassador Insurance Company.

He is a member of the Association of the Bar of the City of New York, and is a member of its Committee on Insurance, of which he was Chairman from 1975 to 1978, where he chairs the Subcommittee on Insurer Solvency; the District of Columbia Bar Association; the Federal Bar Association; and the American Bar Assocation, where he serves on the Tort and Insurance Practice Section and the Section on International Law.

George G. Mader, AICP

George Mader received a B.A. with a major in geography in 1952 from UCLA and a Master of City Planning degree from U.C. Berkeley in 1956. He spent 1958-59 as a Fulbright Scholar at the Technological University of Delft in the Netherlands studying city planning in Western Europe. From 1955 to 1958 Mr. Mader was an associate planner on the special staff that prepared the San Mateo County General Plan. From 1959 to 1962 he was senior planner in charge of the current planning division for the San Mateo County Planning Commission.

In 1962 Mr. Mader joined William Spangle and Associates and today is President. As a representative of the firm, he has served as Town Planner for the Town of Portola Valley since 1965 and for the Town of Los Altos Hills from 1968 to 1975. He has prepared background studies for general plans, general plans, and zoning, subdivision and site development regulations. He has performed special studies of slope-density zoning, and has been instrumental in developing new plans and regulations responsive to geologic and seismic hazards. He developed detailed plans for transfer of development credits in sensitive hillside areas of the cities of Claremont and Milpitas.

Mr. Mader has been actively involved in many of the firm's research projects. He was Principal Investigator for a two-year National Science Foundation study of post-earthquake land use planning and recently headed a study of the response to seismic and volcanic warnings in the Long Valley area of California. He consulted for a geotechnical firm establishing approaches for rebuilding the earthquake-damaged city of Ech Cheliff in Algeria and is a member of the project team for the United States-Mexico Earthquake Preparedness Project to improve earthquake safety in the San Diego-Tijuana border area. Under a National Science Foundation grant, he is documenting the Portola Valley experience in use of geologic information in planning.

Mr. Mader has participated in many state, national and international committees and workshops as a spokesman for land use planning to reduce risk from natural hazards. He was a member of the California Seismic Safety Commission from 1975 to 1984 and chairman from 1979 to 1981. He chaired committees for the Commission evaluating State requirements for seismic safety elements and the Special Studies Zones Act. He has served on committees of the President's Office of Science and Technology Policy, the National Research Council, and the National Science Foundation, and also has participated in review groups convened by the United States Geological Survey. He is currently a Policy Advisory Board member for the Bay Area Regional Earthquake Preparedness Project.

Mr. Mader taught city and regional planning courses for U.C. Extension, Berkeley from 1960 to 1964 and was a lecturer in the U.C. Department of City and Regional Planning from 1967 to 1970. He is a senior lecturer in the School of Earth Sciences at Stanford University where, since 1970, he has taught courses in the application of the earth sciences in city and regional planning.

Mr. Mader is a member of the American Planning Association and the American Institute of Certified Planners. Before the consolidation of the American Institute of Planners and American Society of Planning Officials, he was a member of both organizations and held offices in the Northern California Section and the California Chapter of AIP.

Frank E. McClure

Frank McClure is a California registered Structural Engineer, Civil Engineer, and Architect. He graduated from Lowell High School in San Francisco in 1941. He received a B.S. in civil engineering with a major in structural engineering in 1944 from the University of California, Berkeley.

He is an Honorary Member of the national earthquake engineering society, the Earthquake Engineering Research Institute. He served as its president from 1986 through 1988. He is also a member of the American Society of Civil Engineers, Structural Engineers' Association of Northern California, Seismological Society of America, and the International Conference of Building Officials.

Mr. McClure is a Senior Structural Engineer Consultant for earthquake engineering at the Lawrence Berkeley Laboratory, University of California, Berkeley. After serving in the United States Navy, Civil Engineer Corps, as Lt. (j.g.) with the Seabees on Okinawa, he returned to San Francisco where he worked for several consulting structural engineering offices, and public agencies. In 1955, he opened his own consulting structural engineering office in Oakland, which later grew into the firm of Frank E. McClure and David L. Messinger, Consulting Structural Engineers. McClure and Messinger provided professional services in all aspects of structural engineering design of public, industrial and commercial buildings, and specializing in earthquake engineering. He took a position as University Engineer, University of California Systemwide Adminstration in 1976 until he joined the Lawrence Berkeley Laboratory in 1978.

His professional expertise is in the field of earthquake engineering, with specialization in earthquake vulnerability assessment, seismic reconstruction, and earthquake loss estimation. He made field investigations and prepared reports on earthquake damage caused by the 1952 Kern County, 1954 Eureka, 1966 Parkfield, 1969 Santa Rosa, 1971 San Fernando, 1975 Oroville, 1978 Santa Barbara, 1980 Livermore, 1987 Whittier and 1989 Loma Prieta California earthquakes, and the 1964 Alaska, 1967 Caracas, Venezuela, and 1985 Mexico City earthquakes.

He has served as earthquake damage evaluation consultant to the insurance industry and federal agencies. He performed early earthquake loss simulation studies to test the application of earthquake insurance with various deductibles to mitigate earthquake losses.

He has served as a member of the Scientific Advisory Committee, National Center for Earthquake Engineering Research, State University of New York at Buffalo; the National Research Council, Committee on Earthquake Engineering; Department of Energy, Natural Phenomena Hazards Panel; Seismology Code

Development Committee, International Conference of Building Officials; and the State of California, Field Act Advisory Board to the Office of the State Architect; and Advisory Panels for the Building Seismic Safety Council.

Earl Schwartz

Mr. Schwartz began his career with the City of Los Angeles as a Civil Engineering Assistant with the Department of Building and Safety in 1956. During his 33 years of service, he progressed through the ranks by competitive examination. He was appointed Chief of the Department's Earthquake Safety Division in 1977, Chief of the Conservation Bureau in 1982, Chief of the Resource Management Bureau in 1984 and Chief of the Mechanical Bureau in 1988. He was promoted in May of 1989 to his present position of Executive Officer.

Mr. Schwartz attended the City College of New York where he received a B.S. Degree in Civil Engineering, graduating in 1956. He moved to California shortly after graduation. Earl is licensed by the State of California as a civil engineer, structural engineer and a fire protection engineer.

He is a member of numerous professional associations. Presently, he serves as a Director on the Structural Engineers Association State Board. He is a member of the Structural Engineer's Association of Southern California where he is currently Vice-President. He is a member of the State of California Historical Building Code Board and the Earthquake Engineering Research Institute.

Earl has been involved with the Los Angeles City Earthquake Hazard Reduction Program for many years and was responsible for development of the Department's Earthquake Safety Division, serving as its first Chief. The Earthquake Safety Division is responsible for strengthening earthquake hazardous buildings.

Dr. Lidia Lippi Selkregg

Professor Emeritus in the School of Public Affairs at the University of Alaska, Anchorage, Dr. Selkregg received her Doctor of Natural Sciences degree at the University of Florence, Italy, in 1943. She is a Certified Professional Geologist, AIPG 2060 and a State of Alaska licensed professional geologist.

From 1971 to 1986 she was a Professor of Resource Economics and Planning and Senior Scientist, Arctic Environmental Information & Data Center at the University of Alaska. From 1968 to 1971 she served as Planning Consultant/Planning Officer on the Federal Field Committee for Development Planning in Alaska. From 1961 to 1968 she served as Technical Director of Planning/Staff Geologist for the Alaska State Housing Authority. From 1958 to 1961 she was Geologist/Geologist/Engineer for U.S. Army Corps of Engineers in Alaska. From 1951 to 1958 she was Geologist for the Illinois State Geologic Survey. From 1942 to 1951 she was a Consultant Geologist, Professor of Natural Sciences and Assistant Professor at the University of Florence, Italy.

Dr. Selkregg has extensive experience related to the 1964 Alaska earthquake. She (a) organized, coordinated, and monitored the activities of the Engineering-Geology Evaluation Group that she established on March 29, 1964, to prepare geologic reports on the effects of the earthquake, including mapping areas of failure, subsidence, and inundation as they affected Anchorage, Cordova, Seldovia, Seward, and Kodiak; (b) organized, coordinated, and monitored the preparation and implementation of geologic studies related to disaster assessment and post-disaster planning for Anchorage, Valdez, Seldovia, Cordova, and Kodiak; c) developed methods for coordination among local, state, and federal agencies and the Office of the Governor for implementation of redevelopment plans; d) served as geologist, planner, and member of the Anchorage Planning & Zoning Commission, assembly, and State Coastal Zone Management Council advising several planning and engineering consultants who have conducted studies on geotechnical hazards including the National Academy of Science, the Municipality of Anchorage, and the State of Alaska; and e) served as a member of the Anchorage Municipal Assembly, instrumental in establishing a geotechnical commission for the city.

She has published extensively in the fields of groundwater geology, planning, and applied sciences. She was principal author of:

The Day the Earth Shook -- Shock and Aftershock. Alaska Academy of Engineering and Science. Report No. 3, Anchorage, Ak. (1984).

Seismic Hazard Mitigation: Planning and Policy Implementation -- The Alaska Case. National Science Foundation CEEB112632 (1984).

Planning for Earthquake-Prone Regions, Proceedings of PRC-USA Disaster Mitigation Through Architecture, Urban Planning and Engineering, Beijing, China, November 2-6, 1981.

Urban Planning in the Reconstruction in Human Ecology Volume, the Great Alaska Earthquake of 1964. National Academy of Science. (1970)

Effect of Good Friday Earthquake on Anchorage, Alaska, and Urban Reconstruction. American Association of the Advancement of Sciences, Alaska Section. (1964)

William Sommers

William Sommers has spent thirty-five years in local government administration both in the United States and abroad. He is currently the Commissioner of Public Works for Cambridge, Massachusetts.

Prior to that assignment he was the Commissioner of Inspectional Services for the City of Boston from 1985 to 1987. Mr. Sommers served as municipal manager in Bensalem, Pennsylvania; Franklin Township, New Jersey; and from 1982 to 1985 as city manager of Englewood, New Jersey, in the New York Metropolitan area. From 1962 to 1982 he was a foreign service development officer with the U.S. Department of State's Agency for International Development (AID) in Thailand, Vietnam, the Phillipines and Egypt, emphasizing local government and development.

Mr. Sommers holds a B.A. in political science from Middlebury College in Vermont and a master's in public administration from Harvard's Littauer Center for Public Administration. He also attended the Fletcher School of Law and Diplomacy at Tufts University.

Mr. Sommers has authored some 25 articles on local government and recently served on the Technical Advisory Committee for the "Rapid Visual Screening of Buildings for Potential Seismic Hazards."

D. Whiteman

APPENDIX B

ESTIMATION BASES FOR RISK ANALYSES OF TECHNICALLY FEASIBLE LOSS-REDUCTION ACTIVITIES

In order to make socioeconomic evaluations of loss-reduction measures within an earthquake insurance context, one must provide data that at the very least can be used to suggest the costs and benefits of these mitigations. This Appendix presents the results of analyses performed to estimate

(1) risk levels (degree of loss) associated with various levels of seismic (earthquake) frequency and intensity,

(2) dollar values for both implementation costs and conditional loss-reduction benefits of analyzed building practices, and

(3) dollar values for both implementation costs and conditional loss-reduction benefits of analyzed landuse measures.

In other contexts, assurance from experts may be convincing for the evaluation of loss-reduction activities. However, for this project, a more thorough approach was needed, and risk analysis is a commonplace insurance practice. Even uncertain risks are provided special treatment in a framework that emphasizes quantitative estimates. Moreover, outside the insurance context, failure to provide meaningful estimates for risk analyses of specific loss-reduction activities suggests that the proposed measures have not received thorough consideration -- that, for instance, dramatic instances have been highlighted without thorough investigation of the phenomenon.

Eguchi et al. (1989) emphasized the varieties of risk analyses possible and the uneven quality of the models used. Current models of the probability of liquefaction-induced ground failure are divergent enough to lead to widely discrepant estimates. Data on building losses that are either caused by or associated with liquefaction have not been systematically gathered. For some risk analyses, divergences of models used may make little or no difference to the results; for others, these divergences may have far-reaching practical implications.

The use of risk analysis to evaluate promising loss-reduction activities results in, for those mitigations for which current probabilistic models are weak, estimates of risk and risk-reduction that are somewhat suspect. These loss-reduction activities lie especially in the landuse area. For these, we suggest more focused research to develop more suitable models so that meaningful risk estimates can be made. For purposes of this project, we use expert judgment to compensate for current modeling limitations. With respect to building measures, controversies exist over adequacy of models, and divergencies in models developed could lead to very different results. Since this project does not include the considerable funding needed for evaluating the sensitivities of risk estimates to diverse models, the estimation bases used here are policy-level only. As the risk analysis report suggests, there are many possible ways to improve current models, and any risk analysis developed at this stage must be provisional.

B.1 Expected Annual Loss Basis for Calculation

The basic method used in Appendices B and C and illustrated in Appendix D is an expected annual loss method. Benefits of a specific loss-reduction activity are treated as reduced expected losses. Reduced expected losses are evaluated in terms of the present value of expected reduced losses over the lifetime of the structure.

The method used for assessing expected annual losses, in its discrete form, is based on the following equation

$$EAL = \sum_{I = I_t}^{I = I_{max}} L_I N_I \qquad \text{(B-1)}$$

Such that

- L_I is the loss for a given type of structure at intensity I
- N_I is the annual frequency of occurrence of intensity I
- I_t is the threshold intensity for damage (here, $I_t = 6.0$)
- I_{max} is the maximum intensity possible (here, $I_{max} = 10.0$)
- I is earthquake intensity (measured in such terms as peak horizontal ground acceleration, peak horizontal ground velocity or Modified Mercalli intensity)

For calculation of direct property benefits, one calculates for a given LRM average annual reduced losses achieved through implementing the specified LRM. Next, one uses a real discount factor such as 3 percent and assumes a given time period such as 80 years for the loss-reduction. Using a standardized discount formula, one can thus estimate the present value of the benefits and compare these with the costs of the loss-reduction measure.

Since we considered many cases in this project, these methods were developed at the University of Pennsylvania into a computer program that also included the analysis of benefits and stakeholder considerations indicated in Appendix C. One of many illustrations is provided in Appendix D. For reconstruction of specific calculations, the reader may select a specific LRM, select a given seismic zone intensity level (Table B-1) and use Table B-5, an assumed facility life-span and an assumed real discount rate, in order to estimate direct property benefits to be compared against costs in Table B-5.

B.2 Sample Intensity Frequency Estimates for Policy-Level Risk Analysis

In the absence of elaborate computer modeling for this project, we developed a simple computerized scheme for modeling various sets of estimates of the frequency of Modified Mercalli Intensity. As indicated in Eguchi et al. (1989), elaborate modeling would require consideration of alternative source zone models, attenuation functions, relative site response factors, and intensity conversion equations as well as the correlation of ground motion estimates for special sites with UBC designated seismic zones (which are determined without respect to relative site response factors).

The simple model used here assumes that the frequency, N_I, of a given Modified Mercalli shaking intensity can be determined in terms of the following equation:

$$N_I = \exp(bI + a) \qquad \text{(B-2)}$$

in which b = the slope coefficient, which directly represents the ratio of frequencies of lower to higher intensities

a = the volume coefficient, which relative to a specific b-value represents the relative frequency of specific intensities

I = Modified Mercalli Intensity (defined in terms of strong ground motion criteria).

This model provides an adequate basis for policy-level risk analysis.

The seismic hazard zones of interest in this risk and decision analysis are 2 (or 2*), 3, and 4. As a first crude approximation, one may assume that the (bedrock) intensities for each of these zones with a 10% chance of non-exceedance in 50 years (or roughly a 475 year return interval) are VII, VIII, and perhaps IX, respectively. These very roughly correlate with peak horizontal accelerations of 0.1g, 0.2g, and 0.4g. However, there may be a wide variation in the actual intensities expected at different sites within these zones as functions of proximity to active faults, local geologic effects, and a variety of other local wave propagation effects. Moreover, based on previous studies, we have allowed the b-value to range from -1.1 to -1.5, the latter being a more typical value for worldwide seismicity and the former suggesting proximity to a fault system with high magnitude potential. (The rule of thumb on p. 30 of Algermissen and Perkins, 1976, roughly corresponds to a b-value of -1.5.)

Based on these considerations and tested in terms of previous intensity estimates, (especially Taylor, Atkisson and Petak, 1981), we have developed Table B-1 to derive a range of possible intensity frequency estimates for the various zones of interest. As compared to Taylor, Atkisson, and Petak (1981), the values proposed here are conservative. As compared to estimates in BSD (1989, p. 22), Supporting Document, the estimates provided here are also conservative. For seismic zone 4, our estimates are more conservative except at intensity X. BSD estimates tend to be low-to-intermediate relative to our seismic zone 3 estimates. For seismic zone 2, BSD estimates tend to be intermediate except that they are lower for intensities VI and VII. The range of values proposed in Table B-1, however, allows for sensitivity analyses of possible outcomes.

TABLE B-1

SUMMARY TABLE FOR DIVERSE INTENSITY ESTIMATES

Seismic Zone(s)	I_{500}	b
2	7.0	-1.5
2* or 3	7.5	-1.2
2* or 3	7.5	-1.5
2* or 3	8.0	-1.5
2* or 3	8.0	-1.2
3	8.5	-1.2
3	8.5	-1.5
3 or 4	9.0	-1.1
3 or 4	9.0	-1.5
4	9.5	-1.1
4	10.0	-1.1
4	9.5	-1.5

Note: I_{500} is the shaking intensity expected every 500 years. b is the value provided in equation (B-1) in order to derive "a" and hence other intensity estimates.

B.3 Estimates of Costs and Conditional Benefits for Analyzing Building Practice LRMs

Given estimates of intensity frequencies for the different macrozones, to evaluate building practice LRMs it is necessary to

- o formulate them in a risk and decision framework,
- o estimate costs, and
- o estimate benefits conditional on the occurrence of specific intensities.

The formulation of loss-reduction activities has been made in terms of contrasts between structural types given the status quo and the mitigated structure relative to building practice LRMs specified and numbered in Table 3-2. For instance, activities numbered 100 through 160 involve implementation of seismic code designs. To illustrate these mitigations, we have selected five representative types of structures for which the loss-reduction activity might be applicable. For sensitivity analysis purposes, we also include the more generic categories from Wiggins and Taylor (1986), which suggest that less seismically resistant buildings tend to perform more poorly than is indicated by some building loss algorithms. In each case, we contrast the status quo (unmitigated) with the mitigated situation. Types of structures have been selected because they either are potentially hazardous structures or they are residential sector structures. Subcases considered also incorporate possible differences in costs for seismic design and retrofit in diverse seismic zones.

Tables B-2, B-3, and B-4 are used to develop and document Table B-5, which contains

- o a full listing of representative subcases for each loss-reduction activity,
- o average cost estimates for implementation, and
- o estimated benefits at different intensities.

Table B-2 contains estimated seismic retrofit costs for various cases. Table B-3 contains estimated conditional benefits for various subcases with respect to seismic design. Table B-3 contains both status quo and mitigated new design estimates of losses expected at different intensities. Table B-4 contains both status quo and mitigated (retrofit) estimates of losses expected at different intensities. Table B-5 thus draws on these tables to develop cost and conditional estimates for proposed building measures, including subcases relating to building types and seismic zones. All estimates in Tables B-2 through B-5 are documented in footnotes (at the end of this appendix).

TABLE B-2

ESTIMATED RETROFIT COSTS FOR VARIOUS BUILDING PRACTICE LOSS-REDUCTION ACTIVITIES

Structural Systems: Original System	Structural Systems: Retrofit System	Seismic Zone	Average Replacement Cost $/ft2	Direct Retrofit Costs: Sources/Notes	Direct Retrofit Costs $/ft2: Range	Direct Retrofit Costs $/ft2: Use	Retrofit Cost % of Replacement (Cost)
Unreinforced Masonry (URM) (Includes Infill Walls)	Partially Reinforced Masonry	2* 3 4	50 60 65	1,2	5 - 40 5 - 50 4 - 72	20 20 15	40 33 23
Non-Ductile Concrete Frames (Cast-In-Place)	1. Semi-Ductile Concrete Frames, or 2. Concrete Shear Walls	2* 3 4	65 70 75	3,4	10 - 40 10 - 45 10 - 50	15 15 15	23 21 20
Concrete Tilt-Up Shear Walls (Pre-1976)	Improved Concrete Tilt-Up Shear Walls (Post-1976)	2* 3 4	30 30 35	5,6,7	1 - 25	3	10 10 8
Pre-Cast Concrete Frames -- Non-Ductile	1. Semi-Ductile Concrete Frames, or 2. Concrete Shear Walls	2* 3 4	60 60 65	8,9	10 - 40 10 - 45 10 - 50	15 20 20	25 33 30
Unbraced Parapets/ Ornamentation (URM, RM, Concrete, etc)	Braced/Removed Parapets	2*,3,4	50	10,11	0.50-1.50	1	2
Dwellings (Wood Frame + Others)		2*,3,4	50	12			
Unanchored to Foundation	Anchored				1.00-1.50	1.00	2
Cripple Wall	Wall Reinforced at Foundation				0.50-1.00	1.00	2
Unreinforced Chimney	Chimney Reinforced, Removed or Replaced				2.00-3.00 3.00-5.00	 3.00	6
Story Over Garage-Unreinforced	Story Over Garage-Reinforced				15 - 25	20.00	40
Mobile Homes (Unbraced)	Mobile Homes (Braced)	2*,3,4	30	12	0.50-1.50	1.00	3

TABLE B-3

CONDITIONAL SEISMIC BENEFITS FOR NEW DESIGN BY SEISMIC ZONE

Structural Systems: Without Seismic Design	Structural Systems: With Seismic Design	Seismic Zone	MMI	Damage = Loss: No New Design: Damage Factor%	Damage = Loss: No New Design: Assumption	Damage = Loss: New Design: Damage Factor%	Damage = Loss: New Design: Assumption	Loss Reduction (% Repl. Cost)
Unreinforced Masonry	Reinforced Masonry	3	6	4.0	(2)	1.0	(3)	3.0
			7	11.0		3.0		8.0
			8	34.0		8.0		26.0
			9	56.0		16.0		40.0
			10	77.0		27.0		50.0
		2*	6	4.0	(2)	2.0	(4)	2.0
			7	11.0		5.5		5.0
			8	34.0		12.0		22.0
			9	56.0		23.0		33.0
			10	77.0		37.0		40.0
Non-Ductile Cast-In-Place Concrete Frame	Ductile Concrete Concrete	3	6	1.6	(5)	1.0	(6)	0.6
			7	5.0		2.8		2.2
			8	13.0		5.6		7.4
			9	15.0		11.2		13.8
			10	40.0		18.6		21.4
		2*	6	2.3	(7)	2.1	(6)	0.2
			7	7.5		5.0		2.5
			8	17.0		10.0		7.0
			9	32.0		16.0		16.0
			10	46.0		24.0		22.0
Concrete Tilt-Up Buildings w/o Seismic	Concrete Tilt-Up Buildings w/Seismic	3	6	4.2	(8)	1.0	(9)	3.2
			7	9.6		2.0		7.6
			8	18.2		7.3		10.9
			9	31.6		13.8		17.8
			10	49.2		22.0		27.2
		2*	6	5.0	(10)	1.5	(11)	3.5
			7	11.6		4.0		7.6
			8	22.0		10.6		11.4
			9	38.0		18.5		20.0
			10	60.0		28.7		30.0
Non-Ductile Precast Concrete Frames	Ductile Concrete Frame	3	6	3.0	(12)	1.0	(6)	2.0
			7	6.5		2.5		4.0
			8	15.3		5.6		10.0
			9	32.0		11.2		21.0
			10	52.0		18.6		33.0

TABLE B-3
(Continuation)

Structural Systems: Without Seismic Design	Structural Systems: With Seismic Design	Seismic Zone	MMI	Damage = Loss: No New Design: Damage Factor%	Damage = Loss: No New Design: Assumption	Damage = Loss: New Design: Damage Factor%	Damage = Loss: New Design: Assumption	Loss Reduction (% Repl. Cost)
		2*	6	4.5	(13)	2.0	(6)	2.5
			7	9.5		5.0		4.5
			8	22.0		10.0		12.0
			9	40.0		16.0		24.0
			10	62.0		24.0		38.0
Wood Dwellings	Wood Dwellings	2*,3	6	2.6	(14)	0.8	(14)	2.0
Unanchored and/or	Anchored and		7	4.8		1.5		3.5
Unreinforced	Reinforced		8	11.0		4.7		6.5
			9	19.7		9.2		11.0
			10	39.8		19.8		22.0
Mobile Homes-	Mobile Homes-	2*,3	6	4.7	(15)	0.8	(15)	4.0
Unanchored and/	Anchored and		7	11.0		3.0		8.0
or Unreinforced	Reinforced		8	17.4		6.0		12.0
			9	30.0		16.0		15.0
			10	48.0		28.0		20.0
Q = 1	Q = 2	2	6	0.13	(16)	0.06	(16)	0.07
(Commercial)	(Commercial)		7	4.5		0.9		3.6
			8	79.4		6.9		72.5
			9	100.0		28.2		71.8
			10	100.0		100.0		0.0
Q = 1	Q = 2	2	6	0.46	(16)	0.28	(16)	0.18
(Residential)	(Residential)		7	14.5		6.5		8.0
			8	29.6		13.3		16.3
			9	63.2		27.4		35.8
			10	100.0		56.2		43.8
Q = 1	Q = 3	3	6	0.13	(16)	0.06	(16)	0.07
(Commercial)	(Commercial)		7	4.5		0.6		3.9
			8	79.4		3.1		76.3
			9	100.0		6.7		93.3
			10	100.0		14.5		85.5
Q = 1	Q = 3	3	6	0.46	(16)	0.20	(16)	0.26
(Residential)	(Residential)		7	14.5		3.0		11.5
			8	29.6		5.9		23.7
			9	63.2		11.7		51.5
			10	100.0		23.4		76.6

TABLE B-4

CONDITIONAL SEISMIC BENEFITS FOR RETROFIT BY SEISMIC ZONE

Structural Systems: Original	Structural Systems: Retrofit	Seismic Zone	MMI	Damage = Loss[1]: As Is: Damage Factor%	As Is: Assumption/Source	Retrofit: Damage Factor%	Retrofit: Assumption/Source	Loss Reduction (% Repl. Cost)
Unreinforced Masonry (URM)	Partially Reinforced Masonry	2*,3,4	6	4.0	(2)	2.8	(3)	1.2
			7	12.0		8.0		4.0
			8	34.0		17.0		17.0
			9	56.0		30.0		25.0
			10	77.0		46.0		30.0
Non-Ductile Cast-in-Place Concrete Frames	a) Semi-Ductile Concrete Frames or b) Concrete Shear Walls	3,4	6	1.6	(4)	1.0	(5)	0.6
			7	5.0		3.4		1.6
			8	13.0		7.0		6.0
			9	25.0		14.0		11.0
			10	40.0		24.0		16.0
		2*	6	2.3	(6)	1.9	(5)	0.4
			7	7.5		5.4		2.1
			8	17.0		11.0		6.0
			9	32.0		20.0		12.0
			10	46.0		30.0		16.0
Concrete Tilt-Up Wall Buildings (Pre '76 UBC)	Improved Concrete Tilt-Up Wall Buildings	3,4	6	4.2	(7)	1.0	(8)	3.2
			7	9.6		2.0		7.6
			8	18.2		7.3		10.9
			9	31.6		13.8		17.8
			10	49.0		22.0		27.0
		2*	6	5.0	(9)	1.5	(10)	3.5
			7	11.6		4.0		7.6
			8	22.0		10.6		11.4
			9	38.0		18.5		20.0
			10	60.0		28.7		30.0
Non-Ductile Pre-Cast Concrete Frames	a) Semi-Ductile Concrete Frames or b) Concrete Shear Walls	3,4	6	3.0	(11)	1.0	(5)	2.0
			7	6.5		3.4		3.0
			8	15.3		7.0		8.0
			9	32.0		14.0		18.0
			10	52.0		24.0		28.0
		2*	6	4.5	(12)	1.9	(5)	2.5
			7	9.5		5.4		4.0
			8	22.0		11.0		11.0
			9	36.0		20.0		16.0
			10	62.0		30.0		32.0

TABLE B-4
(Continuation)

Structural Systems		Seismic Zone	MMI	Damage = Loss[1]				Loss Reduction (% Repl. Cost)
				As Is		Retrofit		
Original	Retrofit			Damage Factor%	Assumption/ Source	Damage Factor%	Assumption/ Source	
Wood Dwellings -Unanchored and Unreinforced	Wood Dwellings Anchored and Reinforced	2*,3,4	6	2.6	(13)	0.8	(13)	1.8
			7	4.8		1.5		3.3
			8	11.0		4.7		6.3
			9	19.7		9.2		10.5
			10	39.8		19.8		20.0
Mobile Homes - Unanchored and Unreinforced	Mobile Homes - Anchored and Reinforced	2*,3,4	6	4.7	(14)	0.8	(14)	4.0
			7	11.0		3.0		8.0
			8	17.4		6.0		11.5
			9	30.0		16.0		14.0
			10	48.0		28.0		20.0
Q = 1 (Commercial)	Q = 2 (Commercial)	3,4	6	0.13	(15)	0.06	(15)	0.07
			7	4.5		0.9		3.6
			8	79.4		6.9		72.5
			9	100.0		28.2		71.8
			10	100.0		100.0		0.0
Q = 1 (Commercial)	Q = 3 (Commercial)	4	6	0.13	(15)	0.06	(15)	0.07
			7	4.5		0.6		3.9
			8	79.4		3.1		76.3
			9	100.0		4.7		93.3
			10	100.0		14.5		85.5
Q = 1 (Residential)	Q = 2 (Residential)	3	6	0.46	(15)	0.28	(15)	0.18
			7	14.5		6.5		8.0
			8	29.6		13.3		16.3
			9	63.2		27.4		36.8
			10	100.0		56.2		43.8
Q = 1 (Residential)	Q = 3 (Residential)	3,4	6	0.46	(15)	0.20	(15)	0.26
			7	14.5		3.0		11.5
			8	29.6		5.9		23.7
			9	63.2		11.7		51.5
			10	100.0		23.4		76.6

TABLE B-5

COSTS AND CONDITIONAL BENEFITS FOR BUILDING MEASURES ANALYZED

Table 3.2 #	SEISMIC ZONE	CONDITION BEFORE IMPLEMENTATION	CONDITION AFTER IMPLEMENTATION	AVERAGE COST TO IMPLEMENT (% RC)	SOURCE/ COMMENT	ESTIMATED AVERAGE LOSS REDUCTION (% Replacement Cost) AT MMI					SOURCE/ COMMENT
						VI	VII	VIII	IX	X	
110, 160	3	Q = 1 (Commercial)	Q = 3 (Commercial)	3		0.1	4	76	93	86	Table B-3
		Unreinforced Masonry	Reinforced Masonry	5	(1),	3	8	26	40	50	
		Non-Ductile CIP Conc Frame	Ductile Concrete Frame	3	(2)	0.6	2	7	14	21	
		Non-Ductile Precast Conc Frame	Ductile Concrete Frame	3		2	4	10	21	33	
		Tilt-up - No Seismic	Tilt-up with Seismic	2		3	8	11	18	27	
		Wood Dwellings - Unanchored	Wood Dwellings - Anchored	2		2	3	6	11	22	
		Q = 1 (Residential)	Q = 3 (Residential)	2		0.3	12	24	52	77	
100, 150	2*	Unreinforced Masonry	Partially Reinforced Masonry	3		2	5	22	33	40	Table B-3
		Non-Ductile CIP Conc Frame	Partially Ductile Conc Frame	2		0.2	2.5	7	16	22	
		Non-Ductile Precast Conc Frame	Partially Ductile Conc Frame	3		2.5	4.5	12	24	38	
		Tilt-up - No Seismic	Tilt-up with Seismic	2		3.5	7.5	11	20	30	
		Wood Dwellings - Unanchored	Wood Dwellings - Anchored	1		2	3	6	11	22	
		Q = 1 (Residential)	Q = 2 (Residential)	1		0.2	8	16	36	44	
		Q = 1 (Commercial)	Q = 2 (Commercial)	2		0.1	3.6	73	72	0	
120	2*	Partially Reinforced Masonry	Reinforced Masonry	1	(2),	1.0	2.0	3.0	4.5	6	(4)
		Partially Ductile Conc Frame	Ductile Concrete Frame	1	(3)	0.5	1.5	2.4	3.0	5	
		Tilt-up	Improved Tilt-up	0.5		0.3	1.0	1.7	2.0	5	
180, 190	3, 4	Unreinforced Masonry	Partially Reinforced Masonry	25	Table B-2	1.2	4.0	17	25	30	(5) and Table B-4
		Non-Ductile CIP Concrete Frame	Semi-Ductile Frame/Shear Wall	20		0.6	1.6	6	11	16	
		Non-Ductile Precast Conc Frame	Semi-Ductile Frame/Shear Wall	30		2.0	3.0	8	18	28	
		Tilt-Up (pre'76)	Improved Tilt-Up	9		3.2	7.6	11	18	27	
		Q = 1 (Commercial)	Q = 2 (Commercial)	20		0.1	3.6	73	72	0	
170	2*	Unreinforced Masonry	Partially Reinforced Masonry	40		1.2	4.0	17	25	30	
		Non-Ductile CIP Concrete Frame	Semi-Ductile Frame/Shear Wall	23		0.4	2.1	6	12	16	
		Non-Ductile Precast Conc Frame	Semi-Ductile Frame/Shear Wall	25		2.5	4.0	11	16	30	
		Tilt-Up	Improved Tilt-Up	10		3.2	7.6	11	20	30	
		Q = 1 (Commercial)	Q = 2 (Commercial)	20		0.1	3.6	73	72	0	

TABLE B-5
(Continuation)

Table 3.2 #	SEISMIC ZONE	CONDITION BEFORE IMPLEMENTATION	CONDITION AFTER IMPLEMENTATION	AVERAGE COST TO IMPLE-MENT (% RC)	SOURCE/ COMMENT	ESTIMATED AVERAGE LOSS REDUCTION (% Replacement Cost) AT MMI *					SOURCE/ COMMENT
						VI	VII	VIII	IX	X	
230	4	Unreinforced Parapet Walls	Reinforced/Removed Parapet Walls	2	Table B-2	0.2	0.7	1.7	2.8	3.8	(6)
170	2*	Unreinforced Masonry	Partially Reinforced Masonry	21	(9)	2.0	6	21	31	38	(8)
		Non-Ductile CIP Concrete Frame	Semi-Ductile Conc Frame/ Shear Wall	12		0.6	3	8	15	21	
		Non-Ductile Precast Conc Frame	Semi-Ductile Conc Frame/ Shear Wall	14		3.0	5	13	21	36	
		Tilt-Up	Improved Tilt-Up	6		3.2	8	12	21	33	
		Q = 1 (Commercial)	Q = 2 (Commercial)	20		0.1	4	73	72	0	
130, 140, 200, 210, 220	2,3,4	Wood Dwelling - Unanchored	Wood Dwelling - Anchored	2	(10) and Table B-2	1.5	2.5	5	8	15	(11)
		Q = 1 (Residential)	Q = 3 (Residential)	2		0.3	12	24	52	77	
240	4	Unanchored Water Heaters	Strapped/Anchored Water Heater	0.2	(13)	0.01	0.1	0.5	1	2	(12)
250, 260	3,4	Unanchored Equipment	Anchored Equipment	2.0	(14)						

The approach taken here permits the general loss-reduction activities to be disaggregated into subcases. The socioeconomic analysis thus provided illustrative ratings of these disaggregated subcases and aggregated them again differently based on these ratings. Likewise, public policy and legal analyses yielded more diverse combinations of subcases than those initially proposed from an engineering standpoint.

Many qualifications need to be made of the results here. First, as indicated in Eguchi et al. (1989), there is no single universally accepted scheme for estimating losses at specific intensities. The conditional estimates produced here could be compared to estimates produced by other schemes in order to determine further the sensitivity of results to diverse estimation methods. Second, the procedures used here employ only mean estimates of costs and conditional benefits. As a result, the scatter among possible cases is ignored. The treatment of outliers or cases with special circumstances, such as clear cases in which retrofits can be achieved more economically, may be ignored. In view of these and other considerations (many of which are discussed in the project risk analysis report), the risk analysis results should be regarded as being chiefly for policy-level purposes.

B.4 Illustrative Decision Alternatives to Analyze Landuse LRMs

As mentioned earlier, it is difficult to develop seismic risk estimation models for landuse measures. Data tend to be lacking for assessing the likelihood and severity of given hazards (except perhaps for the occurrence of surface fault rupture in well-defined fault zones of deformation) and for estimating the degree of loss from these hazards. Moreover, unlike building measures, landuse measures often involve real estate considerations other than structural replacement and/or retrofit costs. For these reasons, the alternatives presented here will be merely for current policy-level analyses. Risk and decision analyses of these alternatives may at least suggest conditions under which various landuse measures may be warranted in socioeconomic terms (such as by virtue of community liabilities that may otherwise be incurred should such measures not be adopted).

Table B-6 summarizes representative landuse measures evaluated in seismic risk and decision analyses. These parallel to a large extent those activities identified in Section 3; however, the loss-reduction activities identified in Section 3 have been listed in Table B-6 in order to develop specific risk and decision outputs. In addition, the view in Section 3 that an Alquist-Priolo Act can be extended to potential ground failures other than surface fault rupture has been broken down into the three major sources of ground failures examined here: liquefaction, landslide, and faulting. Results of risk and decision analyses can be combined to consider measures that incorporate all three sources in one measure.

TABLE B-6
REPRESENTATIVE LANDUSE MEASURES
FOR POLICY-LEVEL RISK AND DECISION ANALYSIS

Number	Brief Description
1000	Purchase (if necessary) existing construction or properties in very active fault zones of deformation (hence in seismic zone 4) and convert to low-density purposes or open space only.
1100	Purchase (if necessary) existing construction or properties in moderately active fault zones of deformation and convert to low-density usage or open space only.
1200	Restrict new development in very active fault zones of deformation (in seismic zone 4) to low-rise residential construction. (Assume that residences and other construction would be designed to seismic code.)
1300	Restrict new development in moderately active fault zones of deformation in seismic zone 4 to low-rise residential construction. (Assume that residences and other construction would be designed to code.)
1400	Restrict new development in moderately active fault zones of deformation in seismic zone 3 to low-rise residential construction. (Assume that residences and other construction would be designed to code.)
1500	In seismic zone 4 as deemed appropriate by geotechnical engineers prior to development, drive piles, use vibro-compaction, or use dynamic deep compaction in order to minimize potential ground failures owing to liquefaction. (Assume that seismic codes are adopted and enforced.)
1600	In seismic zone 3, as deemed appropriate by geotechnical engineers prior to development, drive piles, use vibro-compaction, or use dynamic deep compaction in order to minimize ground failures owing to liquefaction. (Assume that seismic codes are adopted and enforced.)
1700	In seismic zone 4 restrict new development in very susceptible liquefaction zones to low-rise residential structures.
1800	In seismic zone 3 restrict new development in very susceptible liquefaction zones to low-rise residential structures.
1900	In seismic zone 4 allow major modifications of existing structures in very susceptible liquefaction zones only for which suitable geotechnical techniques can be used to minimize hazards resulting from ground failures.
2000	In seismic zone 3 allow major modifications of existing structures in very susceptible liquefaction zones only for which suitable geotechnical techniques are used to minimize hazards resulting from ground failures.
2100	In seismic zone 4, in very susceptible landslide locales, restrict new development to open-space uses.
2200	In seismic zone 3, in landslide locales, restrict new development to open-space uses.
2300	In seismic zone 4 purchase (if necessary) land and/or severely damaged construction and convert existing development in very susceptible landslide locales to open-space uses.
2400	In seismic zone 3 purchase (if necessary) land and/or severely damaged construction and convert existing development in very susceptible landslide locales to open-space uses

In Table B-6, loss-reduction activities 1000, 1100, 2300, and 2400 involve purchase of existing properties. For policy-level risk and decision analyses, we assume that the structures purchased have been rebuilt elsewhere -- presumably on locations without severe ground failure potential. We further assume that the strong ground motions expected in the new locations are no worse than those in the fault zone of deformation or landslide zone. In practice, these options may not be available in a few jurisdictions. (E.g., Davis County, Utah, has limited options.) Land for development may be limited to fault zones of deformation, high liquefaction or landslide susceptible zones, or regions with high relative strong motion site response factors. Even where better options are available for seismic hazards, other natural hazards may further constrain available options.

Table B-7 supplemented by Table B-8 is designed to illustrate costs of loss-reduction activities. Even though the benefits of such measures as 1000, 1100, 2300, and 2400 may be high, the costs are often extreme. It is anticipated that there will be only special circumstances under which such loss-reduction activities could be warranted in socioeconomic terms. These circumstances include extreme life-safety risks, extremely high mandated insurance premiums, or buildings that are approaching the end of their life-cycle but whose functions are vital or extremely remunerative.

TABLE B-7
POLICY-LEVEL COST CONSIDERATIONS FOR LANDUSE LRMs ANALYZED

Number	Description of costs (all presuppose mapping, survey, testing, and administrative costs)
1000, 1100	Costs of properties purchased. These may be low or high depending on market considerations. Cost of properties includes land values and for existing construction the market value of structures. Relocation and other costs may be involved. Assume 2x (replacement value of structure) as a rough estimate of these variable costs.
1200, 1300, 1400, 1700, 1800	Loss of market value of properties zones for commercial, industrial, or high-occupancy residential usage.
1500, 1600	Costs of liquefaction mitigation techniques if and as required. Based on Table B-2, Table B-8, and 1988 Building Valuation Data for Los Angeles, we assume that costs are 2-3 percent of replacement costs except for dwellings, for which costs are as much as 10 percent of replacement cost but which could be reduced to perhaps 4 percent if piles were provided for many wood frame dwellings in a tract.
1900, 2000	Costs for existing structures are perhaps double those for LRMs 1500 and 1600.
2100, 2200, 2300, 2400	Cost of land (assume to be a percent of replacement cost)

TABLE B-8
SAMPLE COSTS FOR PROJECTS TO MINIMIZE LIQUEFACTION/SETTLEMENT PROBLEMS IN NEW DEVELOPMENTS

STRUCTURE TYPE	COST NORMAL FOUNDATION[1]	LIQUEFACTION MITIGATION TECHNIQUE: 1. DRIVE PILES		2. VIBRO-COMPACTION		3. DYNAMIC DEEP COMPACTION		AREA SqFt
		TOTAL	COST/SqFt[2]	TOTAL	COST/SqFt	TOTAL	COST/SqFt	
8-story Commercial	$423,200[4]	$423,200	$18.80	$254,250	$11.30	$105,300	$4.68	22,500
3-story Commercial	$180,000[3]	$195,800	$5.44	$381,600	$10.60	$158,040	$4.39	36,000
2-story Apartment		$37,270	$2.66	$180,600	$12.90	$74,760	$5.34	14,000
School		$82,820	$3.66	$194,812	$8.62	$108,480	$4.80	22,600
House		$20,700	$2.35	$120,912	$13.74	$50,072	$5.69	8,800

[1] These are extra foundation costs required to prevent excessive settlements in loose sands (exclusive of seismic concerns).

[2] Cost per square foot is for area of building footprint (not total floor area).

[3] Figure represents cost of excavation and recompaction of upper 10 feet of loose sands, including dewatering. However, any of the 3 techniques for liquefaction mitigation could be selected here for preventing nonseismic settlements.

[4] Figure represents cost of pile foundation.

Loss-reduction activities numbered 1200, 1300, 1400, 1500, 1600, 1700, 1800, 2100, and 2200 pertain to restrictions on new developments. As this report has consistently emphasized, seismic decisions made or omitted in the siting and design phases are often the most critical in terms of cost-effectiveness. What is chiefly lost in loss-reduction activities 1200, 1300, 1400, 1700, and 1800 is the value of land for commercial/industrial/public and high occupancy residential purposes. The value of land is reduced completely to open-space uses in activities 2100 and 2200. These reductions in the value of land can be considerable in some regions of the country. However, further economic and legal analysis is needed to determine whether or not the externalization of natural hazard losses in land values is one factor (whether small or large) in current market values.

Loss-reduction activities numbered 1900 and 2000 deal with major modifications of existing properties. In these cases we shall assume that seismic retrofit is performed. Moreover, for structures with definite and severe potential problems of liquefaction-induced ground failure, we shall assume that geotechnical engineering techniques are used to eliminate or minimize potential ground failure hazards. Table B-8 summarizes costs for various sample projects used prior to development. In dealing with potentially deep subsurface liquefaction potential, and in securing the building against likely liquefaction problems at depth, we assume that piles or vibro-compaction techniques are used, whichever is less expensive. Deep dynamic compaction(DDC) techniques may be used but may be less effective. Even with the use of piles, some further densification may lead to damage of the structure. Comparing these cost estimates with 1988 building cost for the Los Angeles region and with replacement costs per square foot as estimated previously in Table B-5, we speculate that costs for non-dwellings run about 2-3 percent of replacement value. Economies of scale exist for implementing these techniques for residential development. Costs for piles for a single new dwelling may run 10 percent of replacement value; for a tract development, costs may be decreased to perhaps 4 percent of replacement value. These cost estimates need to be further considered in future studies. For illustrative purposes only, we assume that costs for existing structures are twice those for new developments.

Table B-9 outlines in greater detail the loss-reduction activities represented and various policy-level conditional benefits. Table B-9 draws largely from intensity frequency estimates discussed in Section B.2 in terms of loss in order to calculate estimates for strong ground motion hazards alone and for diverse structural classes. As with the estimation of conditional benefits from structural loss-reduction activities, each subcase is developed to represent a category of structure and a status quo situation is contrasted to a mitigated situation in terms of direct structural property benefits.

TABLE B-9

CONDITIONAL BENEFITS (% of replacement cost for structure only) FOR LANDUSE MEASURES (including subcases as defined in the table)

Number		Definition of Subcase (both status quo = S and after mitigation = A in terms of structure type)	Expected Loss at Specified Intensity				
			Intensity				
			VI	VII	VIII	IX	X
1000		In very active fault zones of deformation, purchase properties and replace elsewhere at sites subject only to strong ground motion (seismic zone 4)					
	1001	S = Unreinforced Masonry	4.0	11.0	34.0	100.0	100.0
		A = Reinforced Masonry	1.0	3.0	8.0	16.0	27.0
	1002	S = Reinforced Masonry	1.0	3.0	8.0	100.0	100.0
		A = Reinforced Masonry	1.0	3.0	8.0	16.0	27.0
	1003	S = Non-ductile cast-in-place concrete	1.6	5.0	13.0	100.0	100.0
		A = Make ductile	1.0	2.8	5.6	11.2	18.6
	1004	S = Ductile c-i-p concrete	1.0	2.8	5.6	100.0	100.0
		A = Ductile c-i-p concrete	1.0	2.8	5.6	11.2	18.6
	1005	S = Non-seismic tilt-up	4.2	9.6	18.2	100.0	100.0
		A = Seismic tilt-up	1.0	2.0	7.3	13.8	22.0
	1006	S = Seismic tilt-up	1.0	2.0	7.3	100.0	100.0
		A = Seismic tilt-up	1.0	2.0	7.3	13.8	22.0
	1007	S = Non-ductile pre-cast concrete frame	3.0	6.5	15.3	100.0	100.0
		A = Ductile pre-cast	1.0	2.5	5.6	11.2	18.6
	1008	S = Ductile pre-cast	1.0	2.5	5.6	100.0	100.0
		A = Ductile pre-cast	1.0	2.5	5.6	11.2	18.6
	1009	S = Unanchored wood dwelling	2.6	4.8	11.0	100.0	100.0
		A = Anchored wood dwelling	0.8	3.0	6.0	16.0	28.0
	1010	S = Anchored wood dwelling	0.8	3.0	6.0	100.0	100.0
		A = Anchored wood dwelling	0.8	3.0	6.0	16.0	28.0
	1011	S = Unanchored mobile home	4.7	11.0	17.4	100.0	100.0
		A = Anchored mobile home	0.8	3.0	6.0	16.0	28.0
	1012	S = Unanchored mobile home	0.8	3.0	6.0	100.0	100.0
		A = Anchored mobile home	0.8	3.0	6.0	16.0	28.0

TABLE B-9 (Continued)

Number		Definition of Subcase (both status quo = S and after mitigation = A in terms of structure type)	Expected Loss at Specified Intensity Intensity VI	VII	VIII	IX	X
1100		Purchase properties in moderately active fault zones and replace elsewhere (seismic zone 4).					
	1101-1102	defined as 1001-1012	Benefits defined as 1001-1012 except that status quo (S) cases are defined as follows at Intensity IX:				
			78.0,	58.0,	57.5,	55.6,	65.8,
			56.9,	66.0,	55.6,	59.8,	54.5,
			65.0,	58.0, respectively.			
1200		Restrict new developments in very active fault zones (seismic zone 4). Assume code adoption, compliance, and enforcement.					
	1201	S = Reinforced masonry A = Reinforced masonry	Use 1002				
	1202	S = Ductile c-i-p concrete A = Ductile c-i-p concrete	Use 1202				
	1203	S = Seismic tilt-up A = Seismic tilt-up	Use 1006				
	1204	S = Ductile pre-cast concrete A = Ductile pre-cast concrete	Use 1008				
1300		Restrict new developments in moderately active fault zones (seismic zone 4). Assume code adoption, compliance, and enforcement.					
	1301	S = Reinforced masonry A = Reinforced masonry	Use 1102				
	1302	S = Ductile c-i-p concrete A = Ductile c-i-p concrete	Use 1104				
	1303	S = Seismic tilt-up A = Seismic tilt-up	Use 1106				
	1304	S = Ductile pre-cast concrete A = Ductile pre-cast concrete	Use 1108				

TABLE B-9 (Continued)

Number		Definition of Subcase (both status quo = S and after mitigation = A in terms of structure type)	Expected Loss at Specified Intensity — Intensity VI	VII	VIII	IX	X
1400		Restrict new developments in moderately active fault zones (seismic zone 3). Assume code adoption, compliance, and enforcement.					
	1401	S = Reinforced masonry A = Reinforced masonry	Use 1102				
	1402	S = Ductile c-i-p concrete A = Ductile c-i-p concrete	Use 1104				
	1403	S = Seismic tilt-up A = Seismic tilt-up	Use 1106				
	1404	S = Ductile pre-cast concrete A = Ductile pre-cast concrete	Use 1108				
1500		Use the least costly geotechnical technique to eliminate or minimize liquefaction-induced ground failures and/or differential settlement (seismic zone 4).					
	1501	S = Reinforced Masonry	1.0	13.5	27.0	27.0	27.0
		A = Reinforced Masonry	1.0	3.0	8.0	16.0	27.0
	1502	S = Ductile c-i-p concrete	1.0	9.4	18.6	18.6	18.6
		A = Ductile c-i-p concrete	1.0	2.5	5.6	11.2	18.6
	1503	S = Seismic tilt-up	1.0	11.0	22.0	22.0	22.0
		A = Seismic tilt-up	1.0	2.0	7.3	13.8	22.0
	1504	S = Anchored wood frame	0.8	9.9	19.8	19.8	19.8
		A = Anchored wood frame	0.8	1.5	4.7	9.2	19.8
1600		Use the least cost geotechnical technique to eliminate or minimize liquefaction-induced ground failure and/or differential settlement (seismic zone 3).					
	1601-1604	defined as 1501-1504	Use 1501-1504 for 1601-1604, respectively				
1700		Restrict new developments in high liquefaction susceptible regions to dwellings and to structures that have used the least costly geotechnical techniques to eliminate or minimize liquefaction-induced ground failures (seismic zone 4).					
	1701-1703	defined as 1501-1503	Use 1501-1503 for 1701-1703, respectively				

TABLE B-9 (Continued)

Number	Definition of Subcase (both status quo = S and after mitigation = A in terms of structure type)	Expected Loss at Specified Intensity: VI	VII	VIII	IX	X
1800	Restrict new developments in high liquefaction susceptible regions to dwellings and to structures that have used the least costly geotechnical techniques to eliminate or minimize liquefaction-induced ground failures (seismic zone 3).					
1801-1803 defined as 1501-1503		Use 1501-1503 for 1801-1803, respectively				
1900	For major modifications of structures, where appropriate use the least costly geotechnical technique to eliminate or minimize liquefaction-induced ground failures and/or differential settlement (seismic zone 4).					
1901-1904 defined as 1501-1504		Use 1501-1504 for 1901-1904, respectively				
2000	For major modifications of structures, where appropriate use the least costly geotechnical technique to eliminate or minimize liquefaction-induced ground failures and/or differential settlement (seismic zone 4).					
2001-2004 defined as 1501-1504		Use 1501-1504 for 2001-2004, respectively				
2100	Restrict new developments in very severe landslide or rockfall locales to open spaces (seismic zone 4). Assume code adoption, compliance, and enforcement.					
2101	defined for reinforced masonry	Use 1002				
2102	defined for c-i-p concrete	Use 1004				
2103	defined for tilt-up	Use 1006				
2104	defined for ductile pre-cast concrete frame	Use 1008				
2105	defined for wood frame	Use 1010				
2106	defined for mobile home	Use 1012				
2200	Restrict new developments in very severe landslide or rockfall locales to open spaces (seismic zone 3). Assume code adoption, compliance, and enforcement.					
2201-2206 defined as 2101-2106		Use 2101-2106 for 2201-2206, respectively				
2300	Purchase properties in severe landslide regions and replace elsewhere (seismic zone 4).					
2301-2306 defined as 2101-2106		Use 2101-2106 for 2301-2306, respectively				
2400	Purchase properties in severe landslide regions and replace elsewhere (seismic zone 3).					
2401-2406 defined as 2101-2106		Use 2101-2106 for 2401-2406, respectively				

For loss-reduction activities 1000, 1100, 1200, 1300, 1400, 2100, 2200, 2300, and 2400 -- pertaining to fault rupture, landslide -- we assume that instances of ground failure lead to total structural loss. This assumption is extreme, as limited data show in Wiggins and Taylor (1986) for fault rupture, landslide, and large flow failure and Wiggins et al. (1978) on Alleghany County landslide losses. More refined studies are needed that relate severity of loss to severity of ground failure.

For loss-reduction activities 1000 and 1200, we assume that all instances of intensity of IX and X are associated with total loss from surface faulting in active fault zones. In specific regions, these assumptions can be improved through risk studies that incorporate probabilities of various severities of surface rupture at various sites in the fault zone of deformation. A given earthquake involving the fault will not rupture at all locations along the fault trace; even where rupture occurs, the severity may be considerably less than the maximum surface displacement within the entire rupture zone. For moderately active fault zones referred to in mitigations 1100 and 1300, we assume that all occurrences of intensity X and that 50 percent of the occurrences of intensity IX result in surface faulting sufficiently severe to cause total structural loss. We make no discrimination among various types of structures with respect to their capacity to withstand various severities of fault movement. We further assume perfect knowledge of the width of the fault zone of deformation.

We make similar assumption for landslide failures. We assume that sites were perfectly identified for these potential displacements and that total constructive loss occurs given these displacements. Moreover, in loss-reduction activities 2100, 2200, and 2300, we assume that severe landslides occur whenever intensities IX and X occur. More refined probabilistic landslide models would lead to probabilities of different severities of ground failures resulting from landsliding failures; such models are currently under research.

Loss-reduction activities 1500, 1600, 1700, 1800, 1900, and 2000 deal with potential settlement/ liquefaction-induced ground failure (other than large flow failure). For these we assume, based on limited empirical data from Wiggins and Taylor (1986), that the loss expected at shaking intensity X corresponds to the loss that would occur should these ground failures occur. We further assume that differential ground displacements occur at intensities VIII, IX or X in highly susceptible liquefaction regions. This latter assumption is extremely cautious. As noted in the risk analysis report, an alternative assumption in San Mateo County is that a maximum of only two percent of locations in regions highly susceptible to liquefaction might suffer surface displacement.

In view of the numerous assumptions that we make here in order to conduct risk and decision analyses of landuse measures, one must be cautioned that the outputs will be for current policy-level discussion. Results assist in ruling out broad measures that are clearly too expensive or whose benefits are slight or in defining further socioeconomic contexts under which specific loss-reduction measures should be implemented.

NOTES FOR TABLE B-2

[1]FEMA, 1988 a-6

[2]Retrofit cost assumes that costs in Los Angeles and the rest of Zone 4 will be lower than in other seismic zones. This is attributed to contractor experience and building department competence gain in areas where retrofit is mandated by ordinance.

[3]FEMA, 1988 a-12

[4]The values for retrofit costs in FEMA Figure 12 where judged to be slightly low, particularly given the high sample bias toward military construction. A value of $15 per square foot was selected as more representative of the average for these types of buildings.

[5]FEMA, 1988 a-14

[6]BAREPP, undated - Tilt-up Building

[7]Dames & Moore experience with tilt-up retrofit is similar to that described in BAREPP document when only roof-to-wall anchorage and roof continuity ties are provided. A value of $1 to $2 per square foot is typical for one-story industrial buildings. A range of $2 to $50 per square foot represents a reasonable range for two- to three-story buildings.

[8]FEMA, 1988 a-14

[9]Sample used in FEMA reference (three buildings) is deemed inadequate and nonrepresentative. Retrofit costs for precast frames should be about the same as those for cast-in-place concrete frames in Zone 2 and up to one-third greater in the more active seismic zones.

[10]FEMA, 1988 a-7

[11]Average replacement costs taken as rough composite of reinforcement masonry and concrete shear wall low rise (one to four story) buildings.

[12]Retrofit costs obtained from contractor's estimating data.

ASSUMPTIONS NOTED IN TABLE B-3

[1]Loss data obtained from ATC-13, Table G.1. Judgmental assumptions made for each structural category are outlined in subsequent footnotes. Facility Classification numbers below are as defined in Table 3.1 of ATC-13.

[2]Unreinforced masonry "as is" damaged factor (DF) estimates are obtained using the following assumptions:

a. The average of ATC-13 Facility Class 75 (URM low-rise) and Facility Class 76 (URM medium-rise).
b. For MMI intensities VI and VII, the "mean best" estimates (MEANB) are used for each facility class.
c. For MMI intensities VIII, IX, and X, a weighted average of "mean best" (MEANB) and "mean high" (MEANH) estimates calculated as follows for each facility class.

[3]Unreinforced masonry "retrofit" damage factor (DM) estimates are obtained using the following assumptions:

a. The average of ATC-13 Facility Class 9 (reinforced masonry low-rise) and Facility Class 10 (reinforced masonry mid-rise).
b. The "mean best" (MEANB) estimates for each facility class.

[4]Unreinforced masonry "retrofit" damage factor (DF) estimates are obtained using the following assumptions:

a. The average of ATC-13 Facility Class 9 (reinforced masonry low-rise and Facility Class 10 (reinforced masonry mid-rise).
b. The average of "mean best" (MEANB) and "mean high" (MEANH) estimates for each facility class.

[5]For seismic Zones 3 and 4 "as is" damage factor (DF) estimates for cast-in-place nonductile concrete frames are obtained using the following assumptions:

a. The average of ATC-13 Facility Classes 87 (low-rise), 88 (mid-rise), and 89 (high-rise).
b. The "mean best" (MEANB) estimates are used for each of the above Facility Classes.

[6]The (retrofit) damage factor (DF) estimates are used for each of the concrete frames (cast-in-place or precast) are obtained using the following assumptions:

a. The average of ATC-13 Facility Classes 18, (ductile frame low-rise), 19 (ductile frame mid-rise), and 20 (ductile frame high-rise).
b. For seismic Zone 3 the "mean best" (MEANB) estimates are used for each facility class.
c. For Zone 2*, the average "mean best" (MEANB) and "mean high" (MEANH) estimates are used for each facility class.

[7]For Zone 2*, the "as is" damage factor (DF) for cast-in-place nonductile concrete frames are obtained using the following assumptions:

a. The average of ATC-13 Facility Classes 89 (low-rise), 88 (mid-rise), and 89 (high-rise).
b. The weighted average of "mean best" (MEANB) and "mean high" (MEANH) estimates are used for each facility class calculated as follows: (2MEANB + MEANH)/3

[8]In seismic Zones 3 and 4, the "as is" damage factor (DF) estimates for concrete tilt-up buildings are obtained using the following assumption: ATC-13 Facility Class 21, the "mean high" estimate.

[9]In seismic Zones 3 and 4, the "retrofit" damage factor (DF) estimates for concrete tilt-up buildings are calculated using the following assumptions:

a. ATC-13 Facility Class 21
b. The average of "mean low" (MEANL) and "mean best" (MEANB) estimates.

ASSUMPTIONS NOTED IN TABLE B-3 (Continuation)

[10]In seismic Zone 2*, the "as is" damage factor (DF) estimates for concrete tilt-up buildings are obtained using the following assumption: The value estimated for Zones 3 and 4 multiplied by 1.2.

[11]In seismic Zone 2*, the "retrofit" damage factor (DF) estimates for concrete tilt-up buildings are obtained using the following assumption: The "mean best" (MEANB) estimate for ATC-13 Facility Class 21.

[12]In seismic Zones 3 and 4, the "as is" damage factor (DF) estimates for nonductile precast concrete frames are obtained using the following assumptions:

a. The average of ATC-13 Facility Classes 81 (low-rise), 82 (mid-rise), and 83 (high-rise).
b. The average of "mean best" (MEANB) and "mean high" (MEANH) estimates for each facility class.

[13]In seismic Zone 2*, the "as is" damage factor (DF) estimates for nonductile precast concrete frames are obtained using the following assumptions:

a. The average of ATC-13 Facility Classes 81 (low-rise), 82 (mid-rise), and 83 (high-rise).
b. The "mean high" (MEANH) estimate for each facility class.

[14]The damage factor (DF) estimates for woodframe dwellings are obtained using ATC-13 Facility Class 1, and the following assumptions:

a. The "mean high" (MEANH) estimate for the "as is" condition.
b. The "mean best" (MEANB) estimate for the "retrofit" condition.

[15]The damage factor (DF) estimates for mobile homes are obtained using ATC-13 Facility Class 23 and the following assumptions:

a. The "mean high" (MEANH) estimates for the "as is" condition.
b. The "mean best" (MEANB) estimates for the "retrofit" condition.

[16]These estimates are derived from Wiggins and Taylor (1986) and incorporate preliminary Coalinga loss data.

NOTES FOR TABLE B-4

[1]Loss data obtained from ATC-13, Table G.1. Judgmental assumptions made for each structural category are outlined in subsequent footnotes. Facility Classification numbers are as defined in Table 3.1 of ATC-13.

[2]Unreinforced masonry "as is" damaged factor (DF) estimates are obtained using the following assumptions:

a. The average of ATC-13 Facility Class 75 (URM low-rise) and Facility Class 76 (URM medium-rise).
b. For MMI intensities VI and VII, the "mean best" estimates (MEANB) are used for each facility class.
c. For MMI intensities VIII, IX, and X, a weighted average of "mean best" (MEANB) and "mean high" (MEANH) estimates calculated as follows for each facility class.

[3]Unreinforced masonry "retrofit" damage factor (DM) estimates are obtained using the following assumptions:

a. The average of ATC-13 Facility Class 9 (reinforced masonry low-rise) and Facility Class 10 (reinforced masonry mid-rise).
b. The average of "mean high" (MEANH) estimates for each Facility Class.

[4]For seismic Zones 3 and 4 "as is" damage factor (DF) estimates for cast-in-place nonductile concrete frames are obtained using the following assumptions:

a. The average of ATC-13 Facility Classes 87 (low-rise), 88 (mid-rise), and 89 (high-rise).
b. The "mean best" (MEANB) estimates are used for each of the above Facility Classes.

[5]The (retrofit) damage factor (DF) estimates for nonductile concrete frames (cast-in-place or precast) are obtained using the following assumptions:

a. The average of ATC-13 Facility Classes 18 (ductile frame low-rise), 19 (ductile frame mid-rise), 20 (ductile frame high-rise), 5 (shear wall low-rise), 7 (shear wall mid-rise) and 8 (shear wall high-rise).
b. For seismic Zones 3 and 4, the "mean best" (MEANB) and "mean high" (MEANH) estimates are used for each facility class.
c. For Zone 2* the average of the "mean best" (MEANB) and "mean high" (MEANH) estimates are used for each facility class.

[6]For Zone 2*, the "as is" damage factor (DF) estimates for cast-in-place nonductile concrete frames are obtained using the following assumptions:

a. The average of ATC-13 Facility Classes 87 (low-rise), 88 (mid-rise), and 89 (high-rise).
b. The weighted average of "mean best" (MEANB) and "mean high" (MEANH) estimates are used for each facility class calculated as follows:

[7]In seismic Zone 3 and 4, the "as is" damage factor (DF) estimates for concrete tilt-up buildings are obtained using the following assumption: ATC-13 Facility Class 21, the "mean high" (MEANH) estimate.

[8]In seismic Zone 3 and 4, the "retrofit" damage factor (DF) estimates for concrete tilt-up buildings are calculated using the following assumptions:

a. ATC-13 Facility Class 21.
b. The average of "mean low" (MEANL) and "mean best" (MEANB) estimates.

[9]In seismic Zone 2*, the "as is" damage factor (DF) estimates for concrete tilt-up buildings are obtained using the following assumption: The value estimated for Zones 3 and 4 multiplied by 1.2.

[10]In seismic Zone 2*, the "retrofit" damage factor (DF) estimates for concrete tilt-up buildings are obtained using the following assumption: The value estimated for Zones 3 and 4 multiplied by 1.2.

NOTES FOR TABLE B-4 (Continuation)

[11]In seismic Zones 3 and 4, the "as is" damage factor (DF) estimates for nonductile precast concrete frames are obtained using the following assumptions:
a. The average ATC-13 Facility Classes 81 (low-rise), 82 (mid-rise) and 83 (high-rise).
b. The average of "mean best" (MEANB) and "mean high" (MEANH) estimates for each facility class.

[12]In seismic Zone 2*, the "as is" damage factor (DF) estimates for nonductile precast concrete frames are obtained using the following assumptions:
a. The average of ATC-13 Facility Classes 81 (low-rise), 82 (mid-rise) and 83 (high-rise).
b. The "mean high" (MEANH) estimate for each facility class.

[13]The damage factor (DF) estimates for woodframe dwellings are obtained using ATC-13 Facility Class 1, and the following assumptions:

[14]The damage factor (DF) estimates for mobile homes are obtained using ATC-13 Facility Class 23 and the following assumptions:
a. The "mean high" (MEANH) estimate for the "as is" condition.
b. The "mean best" (MEANB) estimate for the "retrofit" condition.

[15]These estimates are derived from Wiggins and Taylor (1986) and incorporate preliminary Coalinga loss data.

FOOTNOTES FOR TABLE B-5

[1]Implementation costs are costs to add seismic design as per current Uniform Building Code (UBC) in areas where seismic design is currently not practiced. In areas where limited seismic design is already implemented, costs may be taken as half of those shown.

[2]See for example (ICBO, 1980) Table 1, page 5-3.

[3]Add 50 percent to costs of measure 100 in Zone 2* as allowance for ductile detailing. Increment cost is shown here (not total).

[4]Zone 2* damage with ductile seismic provisions is taken as average of Zone 2* without ductile detailing and Zone 3. Values shown are increment loss reduction beyond 120 (not total). See Table B-4.

[5]Although the measure could affect new construction as well as existing buildings, assumed loss reductions are based on the assumption that the measure causes existing buildings to be retrofit. This is without an assessment of what fraction of all buildings of the indicated type will be so affected by this specific measure. Listed are only those key building types for which a hazardous rating is given.

[6]"As-is" loss for parapets are taken as 15 percent of "as-is" losses for unreinforced masonry, as given in Table B-4. "Retrofit" loss is taken as 10 percent of retrofit loss for URM as given in Table B-4. Loss reduction values shown are differences of the above.

[7]Loss reductions for Zone 3 essential buildings are taken as those for retrofit of existing buildings. This is based on the assumption that in most of Zone 3, seismic design is currently practiced for new buildings. However, the loss reductions for each given MMI are judgmentally taken as 80 percent of the loss reductions for Zone 4 for the following reasons:

a. Lower design forces
b. Less developed "infra-structure" of competence in engineers, contractors and construction trades in Zone 3 relative to Zone 4.

[8]For Zone 2*, it has been assumed that the results of this measure are both to obtain code level seismic design where none previously existed, and to result in the upgrade of existing buildings to some reduced criteria. Next, it is assumed that measures 100 and 120 are implemented. Therefore, the loss reductions given here are the average of loss reductions for new constructions in Zone 2* (the sum of measures 100 and 120) and the loss reduction for retrofit of existing buildings in Zone 2* (the values given for Zone 2* in measure 170).

[9]See note 8. The cost of implementing this measure is taken as the average of costs for new construction and of costs for retrofit of existing buildings in Zone 2*. Also, see Table B-2, and note 1 above.

[10]Measures 130 and 140 are less for wood-frame construction. Implementation cost is based on retrofit of cripple stud walls and foundation anchorage only.

[11]Given limited degree of retrofit as described in note 10, average loss reduction is taken as 80 percent of loss reduction estimated for remediation of all key deficiencies (those indicated in Table B-4).

[12]Average loss reduction is based on the assumption that dwelling (apartments and condominiums) loss in fire following earthquake would be complete (100 percent) for percentage of total dwelling inventory shown.

[13]Judgmentally estimated.

[14]Retrofit costs for equipment are taken as percent of equipment costs--not building.

APPENDIX C

ESTIMATION BASES FOR EFFICIENCY AND ALLOCATIVE ANALYSES

C.1 Considerations Affecting Economic Efficiency Analysis

In addition to initial outlay costs and estimates of direct property benefits for specific loss-reduction activities, we have considered the following associated costs and losses in aggregate benefit-cost analyses:

- o costs associated with temporary housing,
- o costs of and losses associated with business interruption,
- o losses associated with injuries and deaths,
- o losses associated with the cost of money (interest on loans), and
- o premium costs (if insurance is purchased).

We have not considered costs and losses associated with the following:

- o contents damage,
- o damage to and damage by water systems and losses resulting from fire following earthquakes,
- o release of toxic or hazardous chemicals,
- o transaction, foreclosure and other similar activities associated with distributive costs and losses (with special caveats for "loadings" associated with premium costs),
- o disaster cleanup, and
- o indirect economic impacts (e.g., effects on prices, unemployment, and their multipliers).

Temporary Housing Costs

If a dwelling is damaged, the homeowner may incur an additional cost if he must find alternative temporary housing. For calculation purposes, we have estimated that for dwellings damaged above 50 percent and whose structural value is $100,000, six months of temporary housing will be needed at a monthly cost of $1,000. Any percentage of damage less than 50 was linearly interpolated to adjust for the temporary housing cost. Investigations of insurance and federal disaster assistance data on temporary housing costs after dwelling damage could improve these assumptions.

due to building structure or equipment damage, as well as the unavailability of needed materials and services. For complex business operations, further analyses may be needed to determine the extent to which damage to business facilities or to pertinent infrastructure facilities may lead to business losses. In some cases, alternative buildings, equipment, materials and supplies, and sources of energy, water, gas, sewage disposal, transportation, and/or other services may be available to continue business and minimize losses.

For simplification we have assumed that business interruption is a function of

- o industry type as denoted by Standard Industrial Classification (SIC) codes,
- o the "q-ratio" of the business (this ratio is defined as the market value divided by the replacement value of the business), and
- o unemployment insurance premiums paid by the business in order to cover short-term unemployment resulting from earthquake damage.

We also have assumed that businesses whose q-ratios are less than one and who are not insured will not re-invest if the earthquake has caused significant damage. This is because the cost to re-invest -- to replace what has been damaged -- is greater than the return that the company expects to earn.

For calculation purposes we have assumed a 10 percent deductible. We have assumed further that only business owners with both earthquake property insurance and earthquake business interruption insurance will be reimbursed by insurers for business interruption losses. We have further assumed that 90 percent of business interruption loss is revenue and that the remaining 10 percent is unemployment.

Losses Associated with Deaths and Injuries

In order to estimate losses associated with deaths and injuries, we have developed interactive parameters for the

- o number of occupants (a function of such factors as time of day, day of week, absentee rates, square footage, and occupancy rates per square footage when fully occupied), and
- o costs of deaths, serious injuries, and minor injuries.

We have followed AIRAC, 1987 (and ultimately Whitman and Cornell, 1976) in relating moderate injuries, serious injuries, and deaths to degree of building damage. We have assumed that minor injuries cost $1,600 and that serious injuries lead to $65,000 for hospitalization and $7,500 in lost wages (see AIRAC, 1987). We have provided two qualified estimates for costs of deaths: a stringent estimate of $300,000 and another estimate of hospitalization and $7,500 in lost wages (see AIRAC, 1987). We have provided two qualified estimates for costs of deaths: a stringent estimate of $300,000 and another estimate of $1,000,000. For project purposes of emphasizing losses in an insurance context, these types of assumptions are appropriate; however, as is well known, use of such estimates should not be taken to imply that the "worth" of a life is reducible to economic terms.

Losses Associated with the Cost of Money

A potentially more controversial element used in this analysis is a real discount rate, used as a means to determine the time-value of money (after discounting for inflation). Investors, businesses, contractors, the elderly, and low-income residents, in many cases, may greatly value marginal amounts of money and so treat money as a commodity to be spent on activities with short-term, rather than long-term payoffs. These stakeholders may prefer very high discount rates, which discourage activities with long-term or uncertain benefits. In contrast, long-term perspectives may be encouraged by parties concerned with larger scale projects or with effects of past and current investments on more distant future prospects. In this perspective actual discount rates may be examined in more aggregate terms, and the real discount rate so evaluated may be lower.

In order to avoid the many and prolonged debates over the suitable discount rate, we have treated the discount rate as having a possible continuum of values. For illustrative purposes, we have developed a three-tier approach, with

- o an 8 percent real discount rate at tier 1 (good investment or expenditure of money even for many with short-term horizons),
- o a 3 percent real discount rate at tier 2 (satisfactory discount rate -- similar to that used for many public projects), and
- o a 0 percent real discount rate at tier 3 (more suitable when life-safety and other public or spillover factors are emphasized).

These discount rates are used in conjunction with interactive assumptions on the effective lifetime of an loss-reduction measure. For illustrative purposes, we have assumed that the structural shells of buildings (in contrast to total buildings, for which extensive remodeling may be done) last 80 years, and that retrofitted structural systems last 30 years. Sensitivity analyses for these assumptions have been performed and are heavily dependent on the discount rate used.

Premium Costs

In Section 2 we argued that, with the possible exception of mandated nationwide primary coverage of selected classes of buildings, probabilistic multisite methods are needed for estimating earthquake insurance rates. These methods incorporate surplus development, expected annual losses, and catastrophic loss potential -- all critical elements in determining the ability of an insurance program to pay off claims as they arise. These methods thus provide means to account for the catastrophic loadings needed for earthquake rates, yet unlike PML methods do not do so at the expense either of not covering expected annual losses or of providing lower rates for higher risks and vice versa.

A prima facie argument can also be developed that mandated national rates (for selected classes of buildings) can, in theory, reduce rates through geographic dispersion which reduces program disturbances caused by rare but catastrophic losses. It is also possible to argue that government involvement in a tax-free reserve fund may provide possible lower rates since greater available reserves reduce the likelihood of insufficient reserves to cover catastrophic losses.

Details of the following matters extend beyond the project scope:

- o administrative, mapping, and other program costs
- o verified behavioral models (e.g., models of the efficiency of private versus public sector involvement, models of response to risk-based versus non-risk-based premiums, models of voluntary purchase of earthquake insurance)
- o careful consideration of intergenerational transfers for any proposed federal program (including transfers that result from making rates initially attractive)

Hence, assumptions made in this project concerning premium costs are crude. These assumptions considered a general loading on expected annual losses (the loading is a function of uncertainties, administrative costs, taxation of reserves, fees, variances of loss distributions, and other possible factors), but do not consider, for instance, effects of risk-based premiums on inducing loss-reduction activities and other factors associated with general federal insurance program construction. In a fuller study of federal earthquake insurance feasibility issues, modeling of these effects would be critical.

C.2 Bases Underlying the Economic Allocative Analysis

In order to develop estimates of costs and benefits to diverse stakeholders, we have included the following stakeholders in our interactive model:

- o owners,
- o mortgage lending institutions,

- o government (federal, state, and local),
- o the federal taxpayer,
- o the state taxpayer,
- o the local taxpayer,
- o insurance companies (covering quake and non-quake, respectively), and
- o employees.

As a result of project workshop discussions, we have also informally included tenants as stakeholders deserving special consideration. For estimating how costs, losses and benefits are distributed among these various stakeholders, we have used or developed provisional models for estimating

- o mortgage default losses,
- o general liabilities, and
- o governmental costs (disaster relief claims).

Mortgage Default Assumptions

The general logic of mortgage default is fairly well understood from the standpoint of lending institutions. Following an earthquake, owners whose property damage exceeds (post-disaster) equity may, all other things being equal (such as q-ratios), decide to default. Should default occur in these cases, lending institutions will sustain part of the loss (remaining mortgage balance plus repair costs plus administrative and transaction costs minus sale value). For simplification, we have assumed that post-earthquake equity (after repairs) equals pre-earthquake equity, and that the property owner will default if the property damage exceeds this equity. Owing to appreciation in land values and to reductions in remaining mortgage balances, after some number of years (perhaps 15 for average land appreciation values given a 30-year mortgage), the equity value is assumed to be greater than any property damage (soil foundation damage excluded). Hence, equity position is a critical interactive parameter affecting potential losses to lenders.

General Liability: Property Damage

It is assumed that the general liability property damage loss potential for earthquakes can be approximated by use of loss-cost factors that were developed using information supplied by members of the AIRAC Earthquake Losses Subcommittee (AIRAC, 1987). These factors are listed in Table C-1 for buildings (excluding single family dwellings) that sustain various degrees of earthquake damage including extensive damage (5 percent to 19 percent value lost), major damage (20 percent to 79 percent value lost), and "total" damage (90 percent to 100 percent value lost).

Table C-1
Loss-Cost Factors for Liability
(AIRAC, 1987)

Possible Outcomes	Degree of Building Damage Extensive 0.05-0.19	 Major 0.20-0.79	 Total 0.80-1.00
Percent with a Claim	0.05	0.37	0.72
Non-suit-pay			
Percentage	0.35	0.30	0.20
Average Amount	360,000	1,300,000	5,000,000
Suit-pay			
Percentage	0.13	0.18	0.31
Average Amount	725,000	2,625,000	10,000,000
Suit-CWP*			
Percentage	0.10	0.15	0.24
Average Amount	175,000	435,000	1,300,000
Non-suit-CWP*			
Percentage	0.42	0.37	0.25
Average Amount	87,000	220,000	650,000

CWP*: Closed without payment

General Liability: Injury Losses

The size of general liability injury losses are also approximated by applying loss-cost factors that were developed based on information supplied by members of the AIRAC Earthquake Loss Subcommittee (AIRAC, 1987). Our estimates of life and injury-related losses are used to determine how many people would sustain minor, major, or fatal injuries and these figures are then used along with estimated percentages of claims filed and settled, with and without pay, to calculate general liability bodily injury losses for our spectrum of possible earthquakes. The numbers used to calculate the general liability bodily injury loss potential are illustrated in Table C-2.

Table C-2
Estimates Used for General Liability
Bodily Injury Loss Potential
(AIRAC, 1987)

	Minor Injury	Major Injury	Fatality
Percent with a Claim	0.15	0.50	0.50
Non-suit-pay			
Percentage	0.34	0.28	0.20
Average Amount	7,000	120,000	177,000
Suit-pay			
Percentage	0.14	0.20	0.31
Average Amount	19,000	205,000	350,000
Suit-pay			
Percentage	0.11	0.16	0.25
Average Amount	5,500	28,000	25,000
Non-suit-CWP*			
Percentage	0.41	0.36	0.25
Average Amount	750	1,600	3,000

CWP*: Closed without payment

General Liability: Workers' Compensation

Workers' compensation is a compulsory system that requires employers to provide no-fault insurance against on-the-job injury and disease, in return for a limited liability against such events. Employers can meet their obligation in three ways: (1) self-insure, (2) purchase insurance from a private carrier, or (3) purchase insurance from a state insurance fund. Not all three options are available in all states. Eighteen states maintain state funds that sell workers' compensation insurance. Six of these are monopolies in states that bar private carriers from selling workers' compensation insurance. The remaining twelve state funds compete with private carriers for business (Butler and Worrall, 1986). To allocate workers' compensation costs between the insurance industry and the government, we have made the simplifying assumption that 70 percent of the costs are borne by private industry and 30 percent are borne by state governments.

Workers' compensation loss potentials can be very roughly approximated by applying loss-cost factors to the estimated overall number of fatalities and minor and serious injuries to persons covered who are at work during the earthquake. Most firms are unable to self-insure either because they are small or because they do not meet the requirements of the state law and, therefore, must buy insurance from either a private carrier or a state agency. It is assumed that 80 percent of employees are covered by workers' compensation insurance and thus that 80 percent of the life and safety costs experienced by a business are covered by workers' compensation insurance. Hence, overall, 56 percent of workers' compensation losses are assumed to be borne by private insurers, 24 percent by government insurance, and 20 percent by workers themselves (less the portion covered by liability).

Governmental Costs

In assessing status quo governmental liabilities as well as governmental liabilities under various forms of earthquake insurance involvement, we have explicitly modeled

- o For homeowners, Small Business Administration (SBA) subsidies in the form of 4 percent, 30-year loans to individuals who do not have credit elsewhere (these apply after a disaster and imply that insurance does not cover the needed funds for repair).

- o For individuals who do not qualify for SBA disaster loans, FEMA sponsors the Individual and Family Grant Program (IFGP) in conjunction with state and local governments; this program provides up to $10,400 (indexed to the CPI for the future) for immediate and necessary expenditures; the average grant is between $2,500 and $3,000 and the program is 25 percent state funded and 75 percent federally funded. (State matching funds may be available in some instances.)

- o For publicly owned buildings, 75 percent federal grants are made in declared disaster areas.

We have not explicitly modeled 8 percent SBA loans to individuals or to businesses affected by disaster. Nor have we modeled general disaster clean-up costs, other than repair of damaged structures.

Stakeholder Costs

In order to distribute both aggregate and allocative costs and losses among various stakeholders, we have assumed that the **general taxpayer** pays those costs modeled for the federal government and that the State or local taxpayer pays those costs modeled for the specific State or local government. These distinctions are made, for instance, because specific states and local governments may transfer earthquake costs to the federal government. As a result, contributions to earthquake costs are not directly in accordance with the risks borne in specific states and municipalities. For state-owned buildings, we have assumed that liability claims may arise as modeled above.

For **insurers** we have assumed that non-quake insurers (and reinsurers) cover various non-quake losses (e.g., fire following, fatalities, workers' compensation, general liability, auto damage, theft). Quake insurers and reinsurers cover damage to structures and contents and any business interruption or temporary housing costs less deductibles and up to limits of liability. These costs are netted against premium income.

For **homeowners** we assume the following costs:

- o the insurance premium costs if they bought insurance,
- o the mitigation cost if they engaged in mitigation,
- o the deductible or amount of earthquake loss, whichever is less if they have insurance (limits of liability are ignored or this analysis),
- o the total cost of damage if they do not have insurance, and
- o the (real) interest on loans necessary to fix any damage.

If homeowners default on their outstanding mortgage, they will lose the equity value in their homes (and bear higher financing costs in the future owing to a bad credit rating). If the homeowners receive grants, this is subtracted from their costs.

Lending institutions are modeled as bearing mortgage default losses as discussed previously. If building owners have insurance we assume that no default occurs since, as a condition of the policy, the claims payment is made to the lender.

Business owners bear the following costs:

- o the insurance premium if they buy insurance,
- o the mitigation costs if they undertake mitigation,
- o the deductible or amount of earthquake property loss, whichever is less, if they buy insurance,
- o the total earthquake loss if they do not buy insurance,
- o the (real) interest on any loans necessary to fix damage,
- o business interruption losses, to the extent that they are not covered by insurance (or otherwise to the extent that there is a deductible or co-insurance clause), and
- o general liability costs, both for bodily injury and for property damage not covered by insurance, or else by a deductible and/or a co-insurance clause.

APPENDIX D
FEDERAL FINANCIAL ASSISTANCE CONSIDERATIONS IN IMPLEMENTING LRMs

In this appendix, we use an illustration in order to show that

- o on the positive side, current federal policies can be used to justify federal assistance and other programs to implement LRMs that in turn will reduce expected federal liabilities, and
- o federal disaster relief policy, regardless of its advantages, currently constitutes a major disincentive to loss-reduction for public and selected private nonprofit buildings,
- o socioeconomic tools such as those developed in this project can be used to evaluate specific programs and proposals to estimate how much federal assistance may be warranted for specific LRMs targeted to reduce expected federal liabilities.

In order to illustrate these conclusions, we have selected an extreme case in terms of building risk. This case represents a public building in seismic zone 4 and with high soft soil site shaking factors (I_{500} = 10, b = -1.1 in Table B-1). We have assumed that the building is an unreinforced masonry (URM) structure, with a remaining 80 year lifetime. Following advice from workshop participants, we have used a three (3) percent real discount rate. Building replacement value has been estimated at 5 million dollars. Other assumptions are found in Appendices B and C. In particular, seismic retrofit cost has been estimated at 25 percent of replacement value and is interpreted as a one-time up-front cost. Hence, as a result of high estimates for the frequency of earthquake intensities, relative to other seismic mitigations for URM construction, benefits will be high (or upper bound). However, relative to LRMs for other selected types of construction, such a concrete tilt-up or wood frame structures, seismic retrofit costs are high. Moreover, costs of seismic mitigations for new construction are far less than for seismic retrofit. Hence, if federal assistance programs make sense for seismic rehabilitation, they make even more sense for new construction.

Table D-1 summarizes benefits and costs of the proposed seismic LRM. Benefits include clear economic benefits of reduced workers' compensation claims. As noted in Appendix C and Section 4, the analysis here does not consider the widest range of possible benefits.

Table D-1

Expected Losses and Benefits of Illustrative Seismic Retrofit

	Expected Losses (Property only)		Expected Benefits or Reduced Losses
	No LRM	LRM	
Annual	$157,600	$96,700	$60,000
Lifetime (3% real discount rate; 80 yrs)	$4,807,200	$2,907,700	$1,899,500

Table D-1 thus illustrates that with a 3 percent real discount rate the proposed LRM has a favorable benefit-cost ratio (1.9: 1.25). With a higher real discount rate, the benefit-cost ratio would be less favorable. With a wider range of benefits included, the benefit-cost ratio would be more favorable.

A favorable benefit-cost ratio does not entail that the benefit-cost ratio is favorable for the owner. In the case of privately owned structures, some of the benefits may accrue to others, such as buildings tenants and visitors. In this illustrative case, we distinguish among the following stakeholders:

- o the local taxpayer -- or the taxpayer insofar as he pays taxes to a specific municipality and so pays for local government expenditures not otherwise funded, and
- o the federal taxpayer -- or the taxpayer insofar as he pays for federal government expenditures.

We have assumed that 75 percent of the expected property (non life-safety) losses are borne by the federal taxpayer and that 25 percent are borne by the local taxpayer. After other earthquakes in the future (see Olsen et. al., 1989), no state or Presidential declaration may be made.

Based on these assumptions, we develop the stakeholder analysis as indicated in Table D-2.

Table D-2

Stakeholder Expected Losses and Benefits from Proposed LRM

	Expected Losses		Benefits (Reduced Losses)
	No LRM	LRM	
Local Taxpayer o 25% of property damage o life-safety o total	 $1,202,000 $1,017,000 $2,219,000	 $727,000 $239,000 $966,000	 $475,000 $778,000 $1,253,000
Federal Taxpayer	$3,605,000	$2,181,000	$1,424,000
Total	$5,824,000	$3,147,000	$2,677,000

Unlike Table D-1, Table D-2 includes an economic assessment of life-safety losses in terms of workers' compensation claims and the like. Given these life-safety economic considerations, the overall benefit-cost ratio of the project is 2.1, or very favorable. Even greater benefits include not only decreased disaster relief costs but also many programmatic advantages of local skilled labor working on a cost-effective project that has important symbolic value for other projects in the local jurisdiction.

However, Table D-1 also shows that for the local jurisdiction, if life-safety considerations are ignored, the benefit-cost ratio is unfavorable (0.6) to the local jurisdiction. Thus, owing to disaster relief assistance availability, benefits of such a seismic mitigation for the state or local government will be less than the costs. Put more succinctly, <u>the presence of disaster relief greatly weakens economic arguments for state or local governments to undertake LRMs</u>. A large share of the potential property losses are "externalized," in this case to the federal government. Incentives for state and local loss-reduction programs are accordingly seriously weakened.

Put positively, Table D-2 shows how a program of federal assistance can be justified to reduce existing contingent federal liabilities. In the extreme case being analyzed, the federal government can provide full assistance to the state and local government to undertake the loss-reductions, and still have a favorable expected effect in reducing the deficit (the benefit cost-ratio is 1.27). In the vast majority of cases in which the overall benefit-cost ratio is favorable, federal cost-sharing can be estimated which nonetheless has a favorable benefit-cost ratio. Hence, although some may desire the use of sanctions to induce state and local governments to undertake cost-effective LRMs, a program of targeted federal cost-sharing may also be warranted, with both potential deficit-reducing and symbolic benefits.